

Study of structure-property relationship in polycrystalline steels based on analysis of EBSD data

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The structure-property linkages are central to the development and deployment of advanced materials in emerging technologies [1]. In this work, we formulate novel, data-driven, assays for exploring the structure-property linkages for structural steel. These assays are built on recent advances in low-dimensional quantification of material structure using correlations and principal analyses of EBSD data, as well as in the mechanical characterization using nanoindentation [2-4]. These novel protocols are demonstrated on a steel 110Г13Л that exhibits rich polycrystalline microstructures.

The comparative analysis of EBSD data obtained for different samples cut made of manganese steel 110Г13Л and received by various methods was made. High-manganese austenitic wear-resistant steel 110Г13Л (Hadfield steel) has the following chemical composition, wt. %: C(0.95-1.50)-Mn(11.5-15.0). The sample surface was studied by method EBSD. The study was made by scanning electron microscope Auriga CrossBeam (Carl Zeiss, Germany) equipped with the EBSD analysis system HKL Channel 5 (Oxford Instruments, UK). The EBSD data acquisition was made by Flamenco Acquisition software (Oxford Instruments, UK). The accelerating voltage of 20 kV and electron beam current of 8 nA were used during scanning. The areas with a size of $20 \times 20 \mu\text{m}^2$ were scanned with a step size of 80 nm. The obtained data was processed and analyzed by Tango software (Oxford Instruments, UK).

Analysis of the diffraction patterns of backscattered electrons allows us to estimate the proportion of low-angle and special grain (CSL) boundaries of a material, to construct a Schmidt factor map and a misorientation histogram of the grains [2, 3]. Uncorrelated misorientations indicate misorientations between randomly selected points in the data set. Correlated misorientations display data between adjacent points, in other words, the angular distribution of grain boundaries. The theoretical curve shows what can be expected from a random set of orientations. The difference between uncorrelated misorientations and the theoretical curve arises, as a rule, due to the strong texture. The presence of a larger specific fraction of low-angle boundaries indicates high plasticity and corrosion resistance of sample. It is known that low-energy and special boundaries of metal grains are highly resistant to destruction. From a materials science perspective, it is important to determine both the ratio of the boundaries of CSL and their distribution in metal. Schmidt factor maps are used to determine the degree of homogeneity of a possible deformation. The Schmidt factor maps were constructed for a slip system typical for FCC crystals: $\{111\} \langle 110 \rangle$ with loading direction parallel to OZ axis. It was previously established that if almost all the boundaries low-angle, the texture is stronger, then the Young's modulus and crystallite hardness, determined by the nanoindentation method, are lower. The decrease in the modulus of elasticity, due to high material texture significantly reduces additional pressure and improves formation mechanical workability of ingot [3].

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